DIVERSION OF FRESH SURFACE AND GROUNDWATER INFLOW FROM THE NORTHERN PART OF THE SOUTH BAY MINE TAILINGS, TOWARDS MUD LAKE.

prepared for:

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Background.

According to Boojum (1994) the water balance and the contaminant loadings for the Mud Lake Drainage Basin show the following parameters for August 29, 1994:

TABLE 1: Water Balance and Contaminant Loading of selected ions, Mud Lake Area (based on Table 4, Boojum, 1994).

	$L.s^{-1}$	$L.s^{-1}$	Percentage of Input Water Balance	Percentage of Mud Lake Contaminant Loading			
				TDS	S	Zn	Fe
Outflow (ML18)	*14.55*						
Inflow (ML 29)		0.66	4.5				
[fresh water input]			}	16.42	12.70	0.86	0.18
Diffused Surface Inflow [fresh water input]		10.18	69.9				
Decant Pond Outflow		3.11	21.4	7.61	4.80	2.59	0.00
Groundwater Inflow		0.61	4.2	75.97	82.50	96.55	99.72

It is obvious from Table 1 that, although groundwater inflow into the Mud Lake Drainage Basin constitutes the smallest fraction in terms of the water balance, it represents the largest contribution to the contaminant loading of the basin and consequently to the outflow of the basin.

The water balance above shows that the largest contributor to the outflow of Mud Lake (ML18, Fig. 1) is the diffused surface inflow of fresh water to the lake. If this input could be reduced significantly, for example: by diversion of this fresh water, then the magnitude of the outflow of Mud Lake would also be reduced significantly and consequently the contaminant load in this outflow. Two different scenarios were considered:

- Reduction of Inflow @ ML29 (Fig. 1) + Diffused Surface Inflow and
- Reduction of Inflow @ ML29 + Diffused Surface Inflow + equal reduction of Decant Pond Outflow.

Based on the inflow rates and the ion loadings as listed in Table 4 (Boojum, 1994), the resultant reduction in the contaminant loadings of the outflow @ ML18 were calculated for selected parameters and plotted in Figures 2 and 3. Figure 2 shows that if a reduction of 75 % of the fresh water inflow to Mud Lake could be achieved, the resultant decrease in the contaminant load @ ML18 is only about 10 % for the TDS and Sulfur content and less than 1 % for the Zinc and Iron content. Figure 3 illustrates that if the fresh water inflow is reduced and at the same time, by an equal percentage, the outflow from Decant Pond, the resultant decrease in the contaminant load @ ML18 is less than 20 % for the TDS and Sulfur content and less than 3 % for the Zinc and Iron content.

Table 1 shows that the only significant contributor to the zinc concentration in Mud Lake is groundwater discharge (inflow). As shown above even a very significant reduction in the outflow of Mud Lake @ ML18 causes only a minor reduction in the zinc concentration .
Figure 4 shows the percentage increase in groundwater discharge which would compensate for this loss. Similarly, the percentage increase in groundwater discharge which would compensate

the loss of the TDS concentration, if the inflow of fresh water and/or the outflow of Decant Pond into Mud Lake is reduced, has been plotted (Fig. 5). A comparison of Figures 4 and 5 illustrates that a reduction of 75 % of the surface water inputs into Mud Lake only requires a marginal increase in groundwater discharge in order to maintain the zinc concentration in the outflow of Mud Lake (M18). In other words, only a very slight increase in the hydraulic gradient in the "Kalin canyon" would be necessary. This increase is considerably less than the monthly fluctuations observed in the "canyon".
On the other hand, a significant increase in the groundwater discharge would be required (i.e. a significant change in the hydraulic gradient) to compensate for the TDS loss (Fig. 5). Such an increase in groundwater discharge would inevitably result in a 20-35% increase in the current zinc concentration (Aug., 1994).

Any significant reduction in the fresh water input coupled with or without a reduction in the outflow from Decant Pond will undoubtedly result in a lowering of the water level of Mud Lake. This in turn will increase the amount of groundwater discharge into Mud Lake, which consequently will lead to an increase in contaminant loading of the outflow of Mud Lake. The only advantage of reducing the input of fresh water and/or Decant Pond outflow water into Mud Lake would be a smaller volume of water which has to be treated biologically for contaminant removal. Furthermore, if the outflow from Mud Lake is reduced, the residence time of water in Mud Lake will, in all likelihood, be longer and biological treatment will be more readily achieved

However, no piezometers have been installed in the aquifer underlying the northern part of Mud Lake and the magnitude of the hydraulic head in this part of the aquifer is not known. Increases in hydraulic head caused by a lowering of the water level of Mud Lake (i.e. reducing the inflow of fresh water and/or the outflow of Decant Pond into Mud Lake) cannot be calculated. Although piezometers have been installed in other parts of Mud Lake (M58, M59, M60A, M60B and M62), there is insufficient information at this time to establish the correlation between the behavior of the water levels in these piezometers and the water level in Mud Lake.
Prior to any modifications to the surface water drainage characteristics it is strongly suggested that a 3D groundwater flow model be constructed of the area from Boomerang Lake to the outflow north of Mud Lake. Although stratigraphic and hydraulic head information is lacking for the northern part of Mud Lake, further EM surveys, conducted this Spring, seem to suggest closure of the buried valley. As a first approximation, the stratigraphy could be projected into this area. With this model different scenarios, for example, lowering or increasing the water level in Mud Lake, can be run and the effect on groundwater discharge, i.e. contaminant loading determined. Once new information becomes available (stratigraphy, hydraulic head, correlation between water levels in piezometers and Mud Lake, etc.), the model can be modified to better reflect the actual conditions.

Another possibility which should be explored is *raising* the level of Mud Lake. If lowering the water level of Mud Lake increases the rate of groundwater discharge, raising the water level should reduce this rate. Computer model studies should provide a reasonable estimate of the cause and effect of this option. It should be possible to build an outflow control structure north of Mud Lake. Detailed stratigraphic information on the subsurface immediately north of Mud Lake is key to this scheme, because under no circumstances can contaminated groundwater be allowed to flow north- or for that matter northeast-ward. Furthermore, it should be realized that an increase in the water level will increase the surface area of the lake and thus the size of the contaminated water body in the area. However, by regulating the outflow from Mud Lake, the residence time of water in Mud Lake can be increased which, in turn, will facilitate biological treatment.

It cannot be emphasized enough that the Mud Lake area is part of an interactive groundwater/surface water flow system and whatever action is undertaken in one specific location will have an effect on another part of the system.

Cost estimates of the work required to achieve any of the options outlined above are premature, because the effect of either option on the entire system should be evaluated by means of simulation studies using a 3D computer model of the entire system, in order to arrive at a first approximation of their feasibility.

Groundwater.

Groundwater is the primary medium which transport the contaminants from the tailings area to the discharge zone in the northern part of Mud Lake. As pointed out in Table 1, it is also the most significant source of the contaminants. The tailings area acts as a significant recharge area for the groundwater flow system. The main source of the groundwater recharge is precipitation in this basin. In addition, to precipitation falling directly on the tailings basin, the tailings basin also receives a groundwater input from the major upland ridge immediately to the northeast of the basin. The bedrock topography map (Vonhof,1995) shows the presence of a northeast-southwest trending tributary to the main north-south buried valley under the Tailings Basin. This bedrock tributary skirts the upland ridge and may extent for some distance beyond the northern and northeastern boundary of tailings basin. The position of the tributary under the northeastern part of the tailings basin, as well as the stratigraphy, is not well defined, because this part of the tailings basin contains Decant Pond and the area immediately outside the dikes is very swampy. In retrospect, once the airhammer drilling equipment was on site, a number of holes could have been drilled through the dikes in this area. Uncontaminated fresh groundwater is present in piezometers M26B and M31 within the tailings basin. Testhole M26B (Fig. 6) is located immediately southwest of Decant Pond in the central part of the tailings basin.

Testholes drilled immediately west and southwest of Decant Pond (M26B, M65, M67, Fig. 6) in 1995 show that a clay layer is present between the aquifer overlying the bedrock surface and the tailings or between the aquifer and Decant Pond. Stratigraphic information from testholes drilled in 1986 north and northeast of Decant Pond (M2, M31 and M33, Fig. 6) do not show any presence of clay. However, as was pointed out previously (Vonhof, 1995), the stratigraphic information collected during 1986 is of questionable value, because significant differences were found in a number of locations where testholes drilled in 1986 and 1995 were in close proximity. The presence of uncontaminated groundwater in the aquifer between the bedrock surface and the clay layer at M26B suggests that the clay layer most likely extends northward and is present under Decant Pond and the tailings in the northeastern part of the tailings basin.

Decant Pond also receives fresh groundwater input from the small upland area located immediately northwest of the tailings basin.

Water levels.

The elevation of the water levels has been measured in piezometers since October, 1986. Figure 7 is an example of the results of these measurements in piezometers in the vicinity of Decant Pond. As can be seen in this figure the water level in the piezometers fluctuates considerably. Similar short term changes can be observed between the water level fluctuations in different piezometers, but the amplitude of the change varies considerably between individual piezometers.

It is obvious from Figure 7 that the record is discontinuous and significant gaps in the data are present. This makes it next to impossible to discern any long-term trends. The only period with regular continuous water level measurements occurs from October 15, 1986 to January 17, 1988. The fluctuation of the elevation of the water level in a number of piezometers completed at different depth both inside and outside the tailings area over this time period is shown in Figure 8. Three additional water level measurements taken in the period from April 8 - June 16, 1988 are also shown. As can be seen in this figure, the trend of the water level fluctuation is very similar between piezometers completed at different depth and in different locations. All piezometer locations show a major rise in the water levels in early Spring (March-April) and a subsequent decline. Shallow piezometers completed in the same environment show considerably more "fine" structure, which reflect a much more direct response to precipitation events. The few measurements between January 17 and June 16, 1988 show the re-occurrence of the Spring recharge effect.

The Fall of 1986 and 1987 (Fig. 8), shows a regular and similar rate of decline of the water levels in the piezometers. Other years, 1989 and 1990, where data happened to be collected during the Fall, confirm this trend (Fig. 7). October is the only month which has water level measurements recorded in 6 individual years over the period 1986-1995. If the contention is true, that the water levels always decline in the Fall than the water levels measured in consecutive years in October can be used, as a first approximation, to determine the long-term trend of the water levels. The elevation of the water levels of different groups of piezometers (i.e. deep and/or shallow, inside and/or outside the Tailings Basin) were plotted in Figures 9 - 12.

Figure 9 shows the trend of deep piezometers both inside and outside the Tailings basin. The following observations can be made:

- there is a relative sharp decline from 1986 to 1987,
- from 1987 the elevation of the water levels in the piezometers <u>inside</u> the Tailings basin increases significantly and in 1995 are invariably higher than in 1986, and
- from 1987 the elevation of the water levels in the piezometers <u>outside</u> the Tailings basin show only a marginal increase and remain below the 1986 elevation.

Figure 10 shows the trend of shallow piezometers inside the Tailings basin. The following observations can be made:

- there is a relative sharp decline from 1986 to 1987,
- from 1987 the elevation of the water levels in piezometers M7N and M26, in the vicinity of Decant Pond, increases significantly and in 1995 is invariably higher than in 1986,
- from 1987 the elevation of the water levels in piezometers H7, H8 and M27N shows an increase, but remains below the 1986 elevation, and
- the deep piezometer M7S shows a trend similar to its twin the shallow piezometer M7N.

Figure 11 shows the trend of a pair of piezometers, shallow and deep, inside the Tailings basin. The following observations can be made:

- there is a relative sharp decline from 1986 to 1987,
- from 1987 the shallow piezometer recovers to a level in 1989 which is higher than in 1986 and subsequently shows slight declines and rises around the 1986 level, and
- from 1987 the deep piezometer shows a steady increase in the elevation of the water level and reaches a value in 1995 which is higher than in 1986.

Figure 12 shows the trend in piezometers outside and north of the Tailings basin. The following observations can be made:

- there is a relative sharp decline from 1986 to 1987,
- from 1987 the elevation of the water levels in piezometers M39, M34, M3 & M33 shows only a marginal increase and remains below the 1986 elevation,
- from 1987 to 1990 the elevation of the water level in piezometer M1 follows the same trend as the other piezometers in this group, but subsequently increases significantly and in 1995 it is considerably higher than in 1986.

Figure 13 illustrates the change in the elevation of the October water level from 1986 to 1995 in shallow piezometers in a cross-section from the western edge of the Tailings Basin to Decant Pond. This figure clearly shows that, since 1993, the water level in the piezometers closest to Decant Pond: H7, M26A and M25 has risen above the level in 1986. Piezometers H8 and M27N do not follow this trend.

The change in the water level of Decant Pond has not been measured regularly over the period 1986 - 1995. . The level according to the topographic map of 1987 was @ 1362.5 ft in October, 1996. The first indication of an increase in the water level was recorded on March 24, 1992, when it was noted that the base of piezometer M25 was flooded, in other words the water level was at least at an elevation of 1363.8 ft, i.e. ground level. This could, however, have been the result of Spring runoff. The second indication was recorded on September 9, 1993, when it was observed that approximately 1 foot of water was present at the piezometer or the water level in the pond was at an elevation of 1364.8 ft. A GPS survey conducted in October, 1995 showed an elevation of the water level @ 1364.7 ft. This means that since 1986 the water level of Decant Pond has risen 2.2 ft and has been, in all likelihood, at this level since at least September, 1993. It also follows, that the surface area of the pond, as shown on the 1987 topographic map, has increased

In summary:

- all piezometers show a significant drop in the elevation of the water level from 1986 to 1987.

- the deep piezometers inside the Tailings Basin show that since 1987 the elevation of the water levels in these piezometers has increased steadily and in 1995 is higher (0.2-0.5 ft) than the first measurement in 1986.

- the shallow piezometers inside the Tailings Basin show a much more varied picture and proximity to Decant Pond appears to determine the trend. Shallow piezometers close to Decant Pond show elevations of the water level in 1995 which are 1.0-1.25 ft higher than in 1986, while piezometers further away illustrate no change or a drop in water level.

- both deep and shallow piezometers outside the Tailings basin show slight increases in the elevation of the water level since 1987, but the elevation in 1995 remains below the 1986 level.

- the water level in Decant Pond has risen 2.2 ft from 1986 to 1993 and has stayed at this level.

Although only one set of measurements (October) is available for the long-term trend analysis over the period 1986 - 1995, the time at which the measurement was taken, during a period of natural and steady decline of the water levels and little or no precipitation input, combined with the consistent pattern that emerged in the trends from the analysis, suggests that the observed trends are real.

It is obvious from the foregoing that the Tailings Basin differs in a unique way from the surrounding area. The following observations can be made:

1. The Tailings Basin is physically isolated from the surrounding surface environment by dikes and is no longer a part of the surface drainage system of the area. This means, that all precipitation is retained within the basin. There is no integrated drainage system within the tailings area and runoff is in part collected in numerous topographic lows and in part directed towards Decant Pond.

2. No perimeter ditch has been constructed to intercept and route runoff from the surrounding uplands away from the area immediately adjoining the dikes. As a result of the disruption in the natural surface drainage system, runoff water does accumulate against the dikes in certain areas (e.g. northeastern Tailings Basin).

3. The dikes appear to have been constructed with very sandy fill on the existing land surface and the accumulated water will flow through the dike and/or under the dike if the appropriate gradients exist.

4. The Tailings Basin is essentially void of macro vegetation (trees, bushes, etc.) and is only sparsely vegetated with mosses, sedges and grasses, while the surrounding area is characterized by spruce and pine forest, muskeg, bushes, shrubs, etc. Soil development is essentially non existent in the tailings area.

5. It is suspected that evapotranspiration by the patchy vegetation cover in the Tailings Basin is less than in the surrounding areas, because the root systems of the existing vegetation are very shallow in the tailings area.

6. The tailings have been covered with a layer of a mixture of sand to coarse gravel varying in thickness from 2-6 inches (5-15 cm). This cover was placed on the tailings to prevent erosion and windblown transport and to provide a base, with the addition of mulch, for re-vegetation. This highly permeable layer provides an excellent initial storage medium for water (precipitation, snow melt) and reduces evaporation subsequent to a precipitation event. At the same time it provides prolonged contact with the underlying tailings for

infiltration. Water retained in this layer will move downslope, but at a much lower rate than overland runoff on fine grained sediments, such as tailings.

7. The tailings at any particular spot within the basin are uniform in size and laterally well sorted due to the relative narrow range of grainsizes in the feed and the depositional environment. Vertically they show greater variability in grainsize as a result of changes in the sediment source (position of spigots), changes in flow pattern within the Tailings Basin due to deposition, etc. As a result the porosity of the tailings is greater than in sediments with the same size range derived from natural sources and deposited in the natural fluvial/lacustrine environment of the Quaternary Period. NOTE: The sediments overlying the bedrock surface in this area were deposited during that period.

8. Mitigating the infiltration of water into the tailings is the oxidized zone at the top of the tailings deposit, which is present in many locations. As a result of oxidation processes various Fe-hydroxides and Fe-oxy-hydroxides have been deposited in this zone. These compounds will decrease the permeability of this zone, but not necessarily the porosity. Downward water transport through this oxidized zone can still occur as a result of capillary movement.

The main groundwater recharge event occurs as a result of Spring melt of the winter snowpack, as was shown in Figure 8. It is not known if, on average, snow accumulation in the Tailings Basin is greater or smaller than in the surrounding area. Crusting of the snowpack will more readily occur in exposed areas such as the Tailings Basin. This crusting will affect the rate of sublimation of this surface. If the rate of sublimation is less in the tailings area than in the surrounding area, the equivalent water content/ m^2 in this snowpack will be greater in the tailings area.

In the foregoing it has been shown that the environment of the Tailings Basin differs considerably from the surrounding area. Most of the points raised could give rise to a higher rate of infiltration of water in the Tailings Basin than in the surrounding terrain, with the exception of the gravel pit area. In addition, there are variations in the annual precipitation.

The long-term trends in precipitation, compiled by Dr. R.O. van Everdingen, and shown here as Figure 14, illustrate that 5 - 7 year “cycles” are present. (NOTE #1: the year runs from October to October and the annual precipitation shown, for example, for 1980 comprises the snowfall from October, 1979 to the Spring, 1980 + the rainfall from the Spring, 1980 to October, 1980. NOTE #2: The climatic data used is from the weather station in Ear Falls, approximately 70 km south of the mine site.)

The variation in the amount of the annual snowfall shows much less variation than the annual rainfall, but, in general, maxima in both types of precipitation are present in the same year. Water level measurements in the piezometers commenced in October 1986. Immediately prior to 1986, there were 2 consecutive years with high annual precipitation. From 1985 to 1987 the annual precipitation shows a significant decline, which occurred in both the snowfall and rainfall component. This decline is also present in the trend of the water levels in the piezometers (Figs. 7-12). The other 2 consecutive years with water level data are 1989 and 1990. The annual precipitation shows an increase over this period, while the water levels show a decrease. However, the 1990 increase in annual precipitation is primarily due to the rainfall component. 1989 on the other hand, had one of the highest snowfalls on record (Fig. 14). which would, in all likelihood, have resulted in greater recharge to the groundwater flow system than the increased rainfall precipitation in 1990. From 1992 there has been a general decline in the annual precipitation. This decline is also suggested by the water level measurements in the piezometers.

In conclusion, the water level trends observed in the piezometers appear to follow, in a general way, the trend of the precipitation, except that several piezometers in the Tailings basin show, in addition to the “precipitation trend”, a general rise in the water level over the period 1987 to 1995.

Decant Pond

Decant Pond is an artificial feature and is locates in the northeastern part of the Tailings Basin. The pond is underlain by tailings on the south and southwest side and is located on the original land surface on the other sides. It receives water input by direct precipitation, runoff from within the Tailings Basin, dike seepage and groundwater discharge. The latter two primarily from the northeast.
The surface of the tailings south and southwest of the shore of Decant Pond rises to an elevation of 1370 ft, about 5-6 ft (1.5-1.8 m) higher than the current level of the pond and the watertable in the tailings is also higher than the pond level. The hydraulic head distribution, in a vertical and horizontal sense, within the tailings is not defined and as a result it is not known if lateral groundwater flow within the tailings contributes contaminated water to Decant Pond. Based on the 1987 topographic map Decant Pond covered 20.9 % of the total area of the Tailings Basin. The rise in the water level has resulted in an increase in the size of the pond to 29.7% of the basin. In other words the 1995 surface area of Decant Pond is 41.87 % larger than in 1987.

The Tailings Basin, including Decant Pond, acts as a recharge basin for the deeper groundwater flow system which in part discharges into Mud Lake. Rises in water levels within the basin will increase the hydraulic head and consequently the movement of groundwater and its dissolved contaminants towards Mud Lake.

Potential measures to reduce the contribution of the Tailings Basin to the groundwater flow system.

A number of the factors which contribute to the unique conditions that characterize the Tailings Basin could be modified in such a way that their contribution to the deeper groundwater flow system is reduced.

The water level in piezometers close to Decant Pond has increased significantly, the deep piezometers completed in the aquifer overlying the bedrock surface also show an increase in the water level. These increases are most likely the result of the observed increase in the elevation of Decant Pond and climatic variables. It is suggested not only to lower the water level in Decant Pond to at least the level of October, 1986, but also to maintain this lower level by means of a flow control structure in the outflow of Decant Pond. A first approximation of the effect of modifying the water level in the pond can be obtained from the computer model mentioned before. It is realized, that by lowering the water level in Decant Pond the contaminant loading of the pond will increase temporarily as a result of lateral drainage from the tailings, which will also stress the biological polishing capacity, until a new equilibrium is reached.

Surface runoff accumulating against the north eastern part of the dike seeps through the dike into Decant Pond. In addition, groundwater flow enters the Tailing Basin in this area. The topographic characteristics of this eastern area are illustrated in a number of cross-sections.

The location of the cross-sections is shown in Figure 15. Cross-section A-A' (Pl. 1) is located immediately east of the dike and runs from Boomerang Lake in a north to northeasterly direction towards piezometer M33. The intercept with cross-sections B-B', C-C' and D-D' is indicated. Cross-section A-A' shows the presence of a significant bedrock high with considerable relief. (NOTE: the position of the bedrock is based on a sketch map provided by M. Berezowsky, Boojum Research).
The northern part shows a low area bounded on the south by bedrock and on the north by a road. The elevation of the low area is about 2-3 ft (0.6-0.9m) below the crown of the dike. The bedrock @ M33 is 18 ft (5.5m) below the ground surface.

Cross-sections B-B', C-C' and D-D' (Pl. 2), drawn at right angles to cross-section A-A' and running more or less in a southeasterly direction, show the topography from Decant Pond to the crest of the major upland east of the pond. The intercept with cross-section A-A' is indicated on the cross-sections.The road shown in each of the cross-sections is the eastern dike of the Tailings Basin. Cross-sections C-C' and D-D' illustrate that the Tailings basin abuts the bedrock upland to the east. Cross-section B-B', on the other hand, shows a gentle upward sloping surface for about 200 ft (60m) east of the road followed by a section of about 100 ft (30m) with an intermediate slope before the land rises more steeply. The steeply rising surface is the bedrock high, the intermediate sloping area most likely represents a talus slope and the gentle rising slope an area with Quaternary sediments and the area most likely underlain by a bedrock valley which continues under the Tailings basin in the direction of piezometer M26.
The area of prime concern is the low area south and near piezometer M33 (cross-sections A-A' & B-B, Pl. 1 and 2, resp.) because it collects surface runoff and is a recharge area for the groundwater flow system under the Tailings Basin. The surface runoff could be intercepted by constructing a ditch from the
bedrock upland (Pl. 1) and routing the water north past piezometer M33 into the muskeg. The depth of the ditch should not be any deeper than the level in the Decant Pond.

The interception of the groundwater flow is more complicated. It would require detailed definition of the hydrogeology and bedrock surface not only along the trajectory of cross-section A-A' but also towards the outflow of Decant Pond. In addition hydrogeological information about the aquifer closer to the bedrock upland will be required in order to define the hydrodynamic head distribution and the magnitude of the groundwater contribution from this area to the Tailings Basin. Subsequently, a bentonite slurry cutoff wall would have to be installed between the ditch and the road (tailings dam). The ditch would then also receive groundwater discharge, because the cutoff wall will result in upward groundwater flow from the aquifer east of the Tailings Basin. Prior to embarking on this rather costly venture, the effect of lowering the water level in Decant Pond should be monitored and its effect on the groundwater regime in the Tailings Basin determined. Furthermore, once the additional but necessary hydrogeological information has been obtained, model studies of the installation and placement of the cutoff wall should be conducted.

Improvement in the vegetation cover in the Tailings Basin. Evapotranspiration would increase as well as greater amounts of precipitation would be intercepted and consequently less water would infiltrate into the tailings. This may require re-contouring of the tailings surface.

Conclusions

Modifications to the water level and/or recharge input parameters of Mud Lake should only be done after the effect on the entire system from "Boomerang Lake - Tailings Basin- outflow of Mud Lake" is known.

The long-term trend of the water levels in piezometers completed within the Tailings Basin shows, in addition to precipitation variables, a further rise in comparison to the water levels completed outside the basin. This additional rise may be solely due to a significant increase in the size of Decant Pond as a result of an increase in the water level of the pond. Increases in hydraulic head in the groundwater flow system under the Tailings Basin will increase the rate of groundwater discharge and its concomitant contaminant load into Mud Lake.

The water level in Decant Pond should be lowered.

The possibility of installing a slurry cutoff wall northeast of the Tailings Basin to prevent groundwater flow from entering the groundwater flow system under the basin should be further explored.

Prior to any modifications, either inside or outside the Tailings Basin, model studies should be conducted to obtain first approximations of their effect.

References Cited

Boojum, 1994. Mud Lake Report, South Bay Project, Talisman Energy Inc, November, 1994

Vonhof, 1995. Test drilling program and piezometer installation, South Bay, Ontario. April 25 to May 14, 1995. October, 1995

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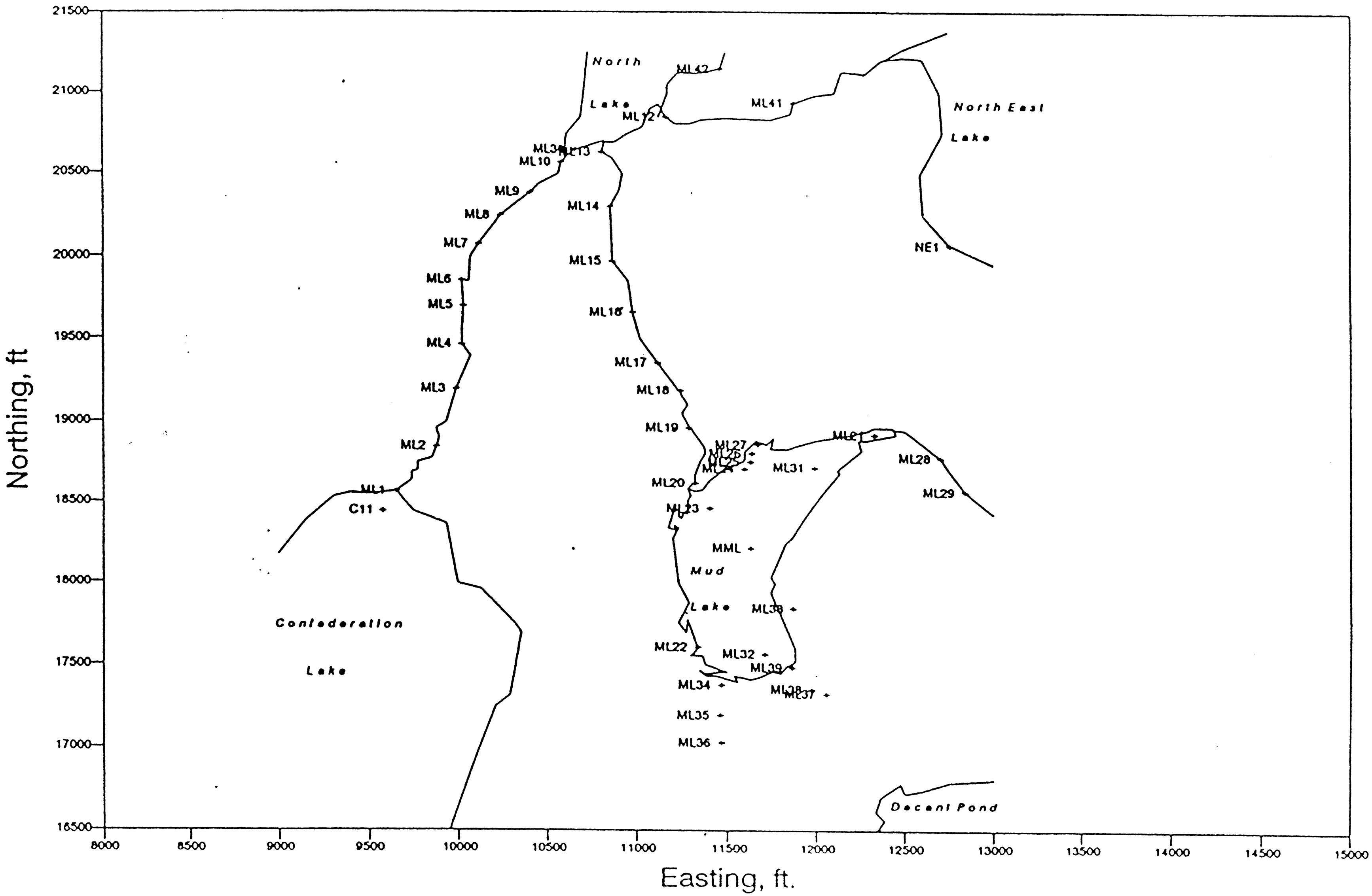


FIGURE 1. LOCATION OF ML 18 AND ML 29, MUD LAKE (after Map 1, Boojum, 1994)

FIGURE 2. PERCENTAGE REDUCTION IN SELECTED ION CONCENTRATION OF OUTFLOW (ML18) BY REDUCING FRESH WATER INPUT INTO MUD LAKE

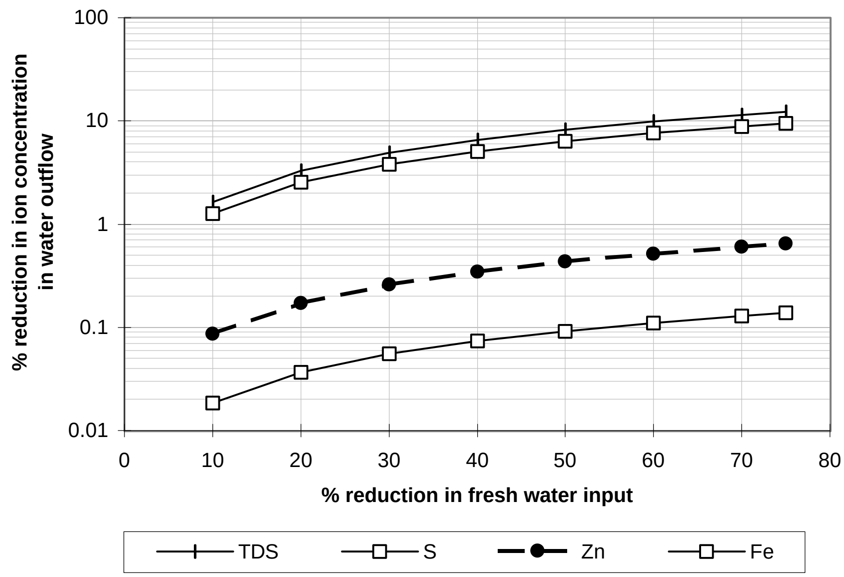


FIGURE 3. PERCENTAGE REDUCTION IN SELECTED ION CONCENTRATION OF OUTFLOW (ML18) BY REDUCING FRESH WATER AND DECANT POND INPUT INTO MUD LAKE

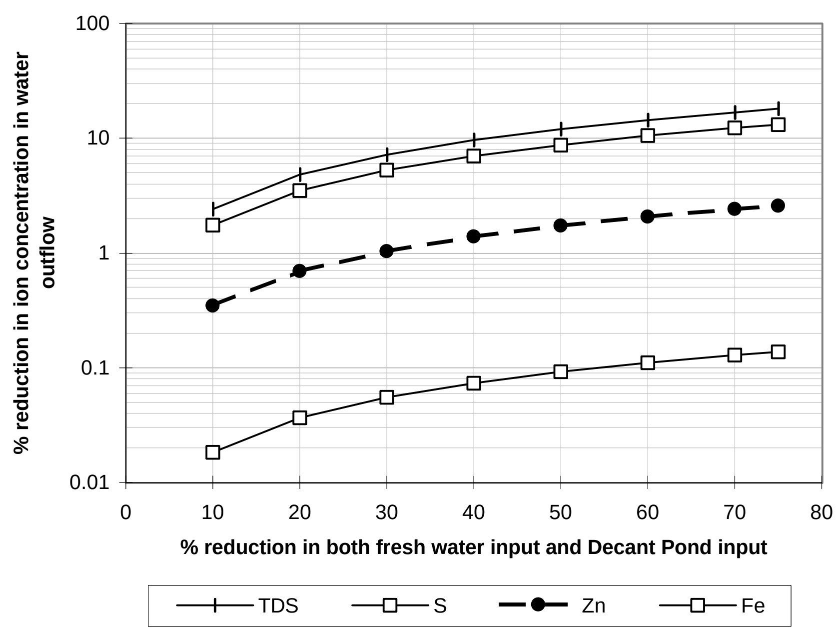


FIGURE 4. PERCENTAGE INCREASE IN GROUNDWATER INPUT INTO MUD LAKE TO COMPENSATE FOR LOSS IN Zn CONCENTRATION @ ML18 RESULTING FROM DECREASE IN FRESH WATER INPUT

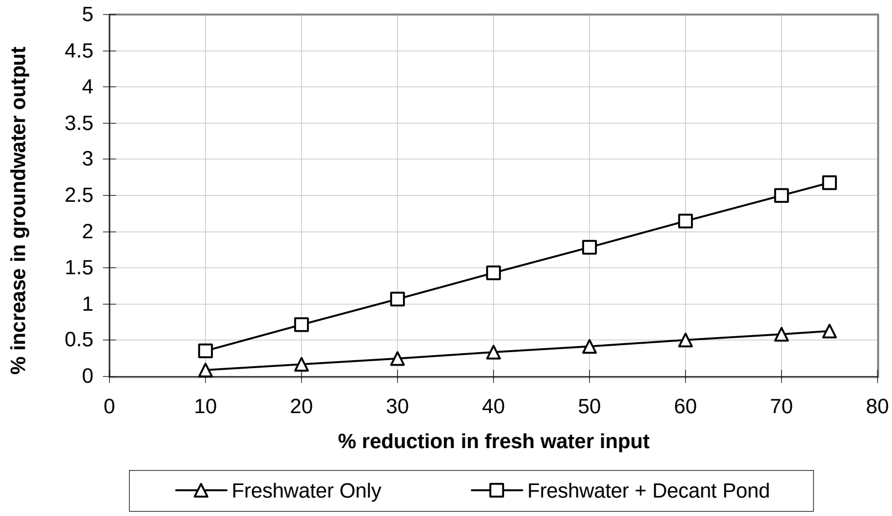
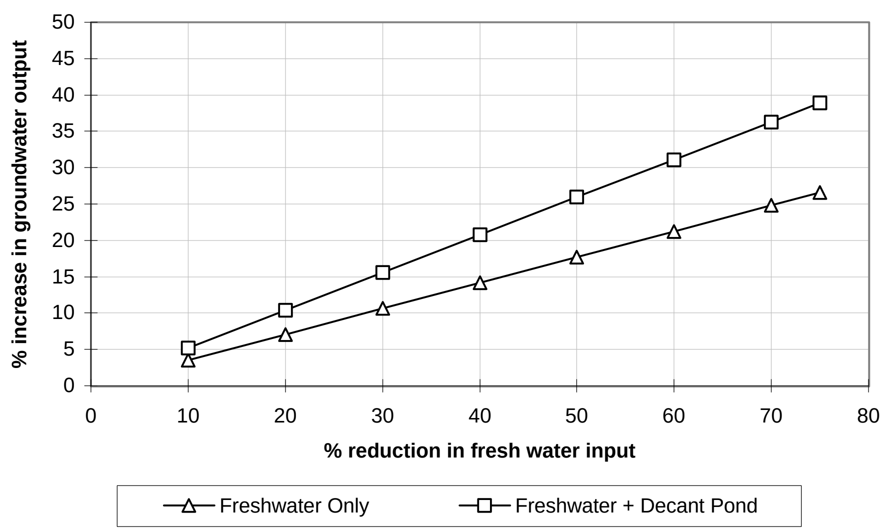


FIGURE 5. PERCENTAGE INCREASE IN GROUNDWATER INPUT INTO MUD LAKE TO COMPENSATE FOR LOSS IN TDS CONCENTRATION @ ML18 RESULTING FROM DECREASE IN FRESH WATER INPUT



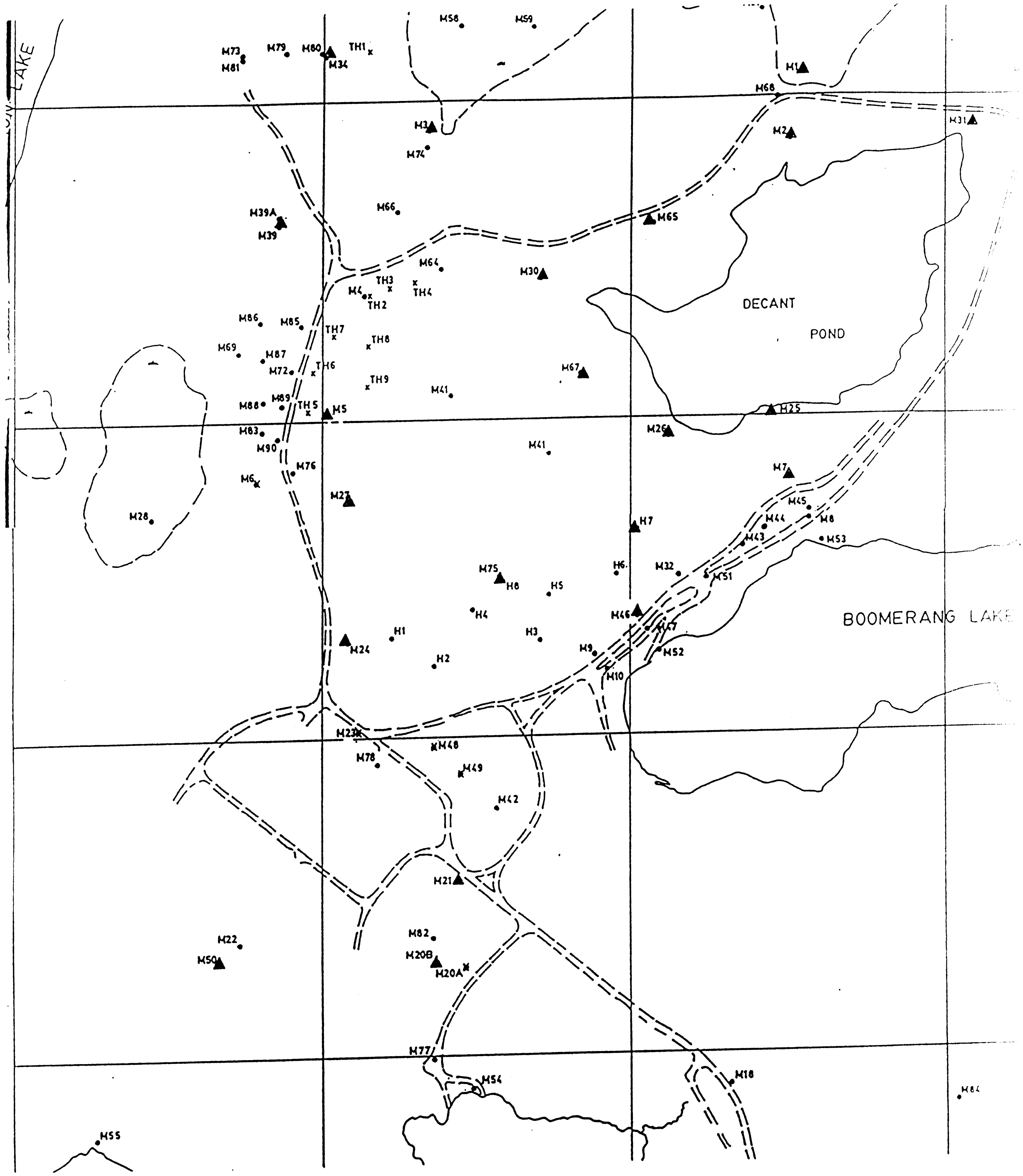


FIGURE 6. LOCATION OF PIEZOMETERS USED IN THIS REPORT

FIGURE 7. ELEVATION OF WATER LEVEL IN PIEZOMETERS IN VICINITY OF DECANT POND VERSUS TIME

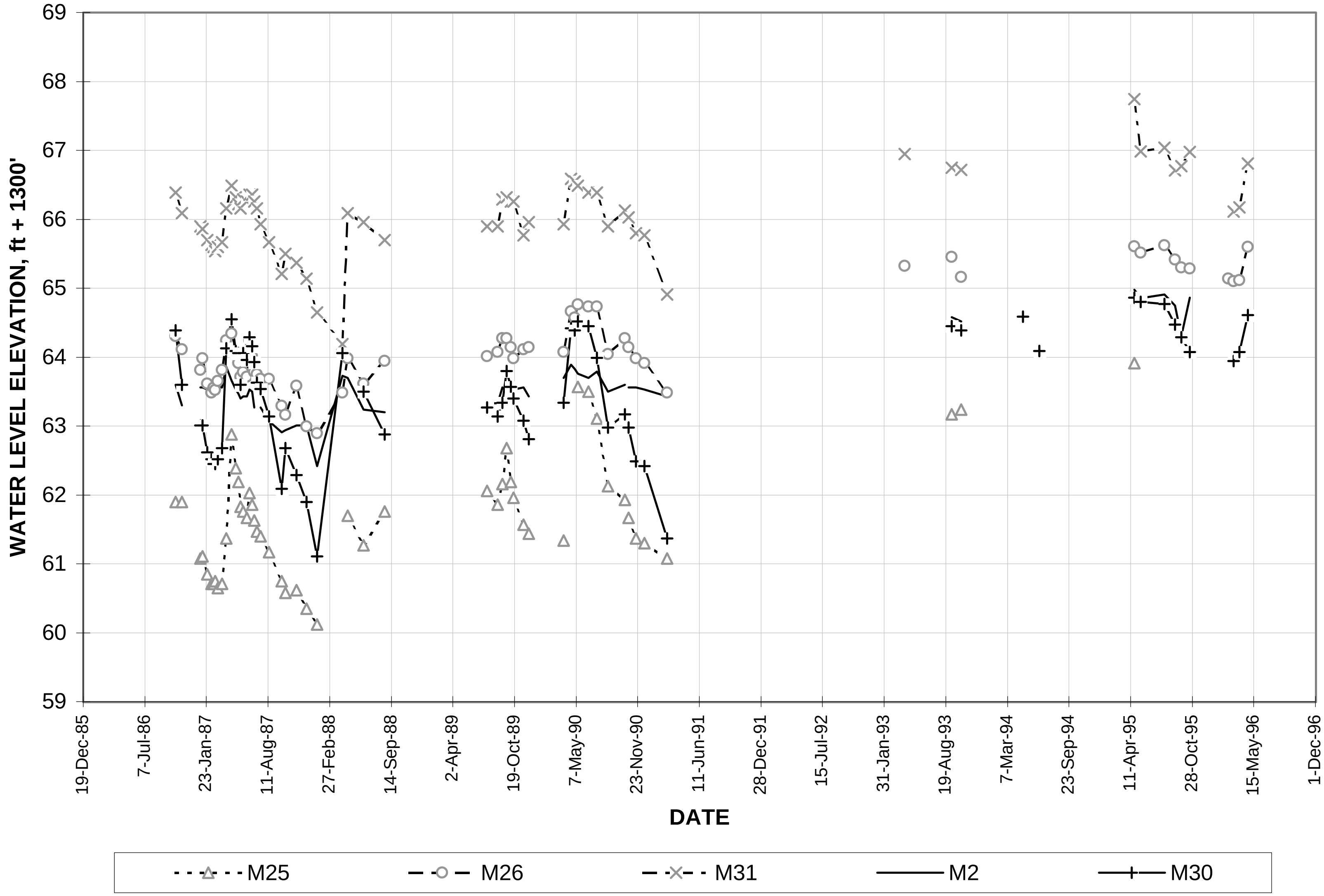


FIGURE 8. ELEVATION OF WATER LEVEL IN PIEZOMETERS M5E, M20, M21, M24W & H7 VERSUS TIME OVER PERIOD OCT. 15, 86 - JAN.17, 1988

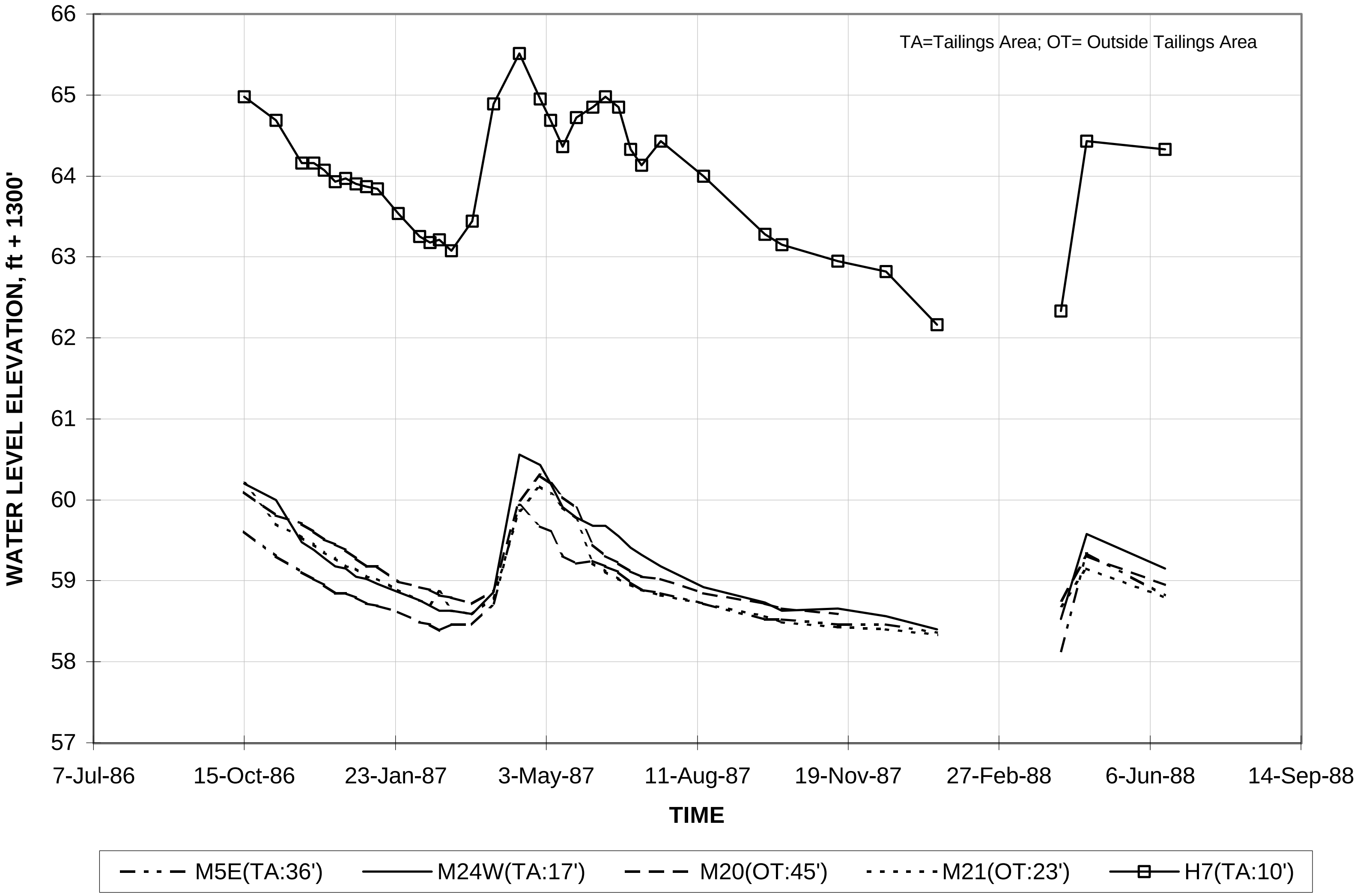


FIGURE 9. ELEVATION OF WATER LEVELS IN OCTOBER FROM 1986-1995: M50, M21, M20, M5E, M46 & M7S (deep piezometers, inside & outside Tailings Basin)

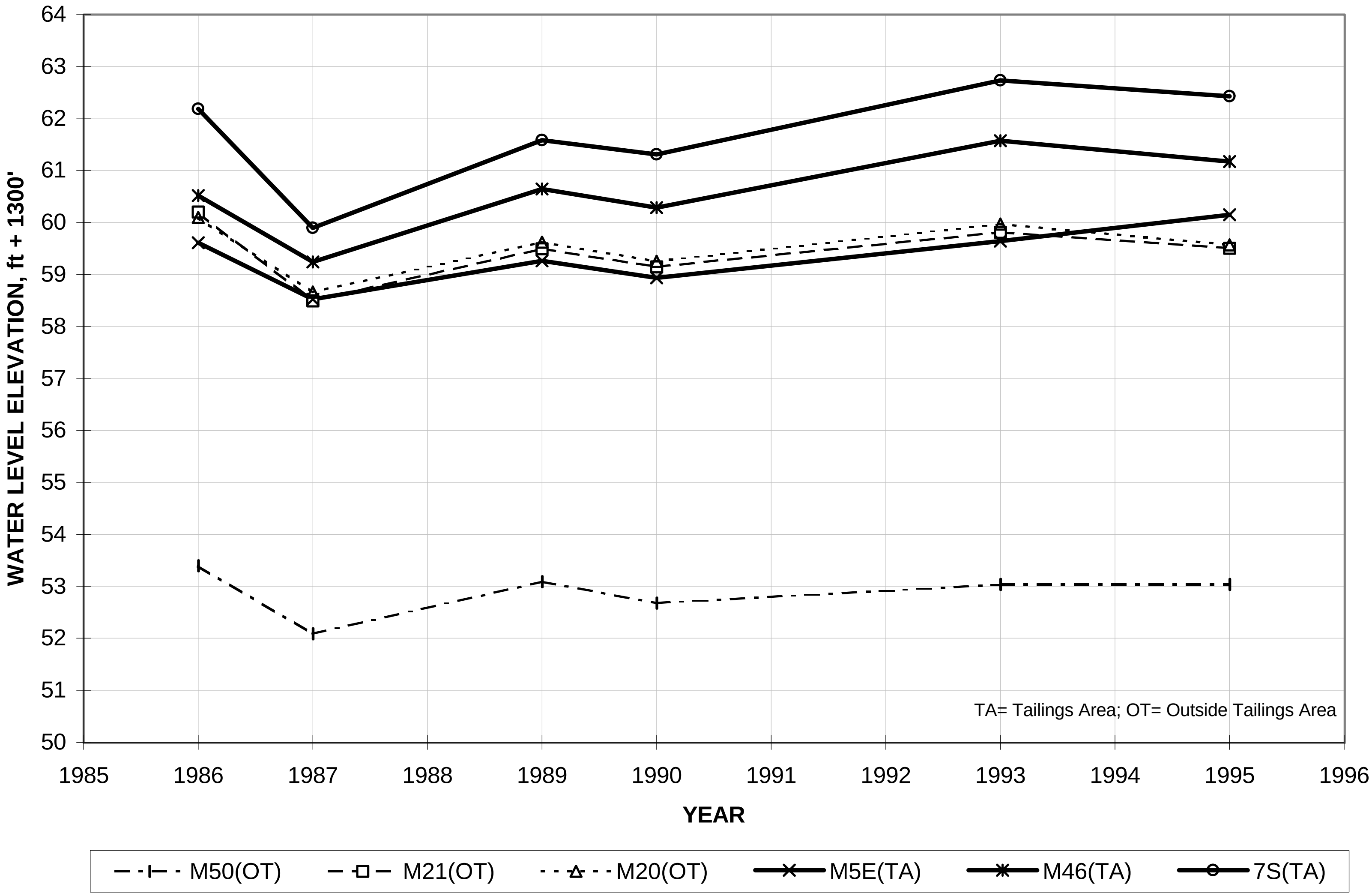


FIGURE 10. ELEVATION OF WATER LEVEL IN OCTOBER FROM 1986-1995: M27N, H8, H7, M26A, M7N & M7S (shallow piezometers, except M7S, Tailings Basin)

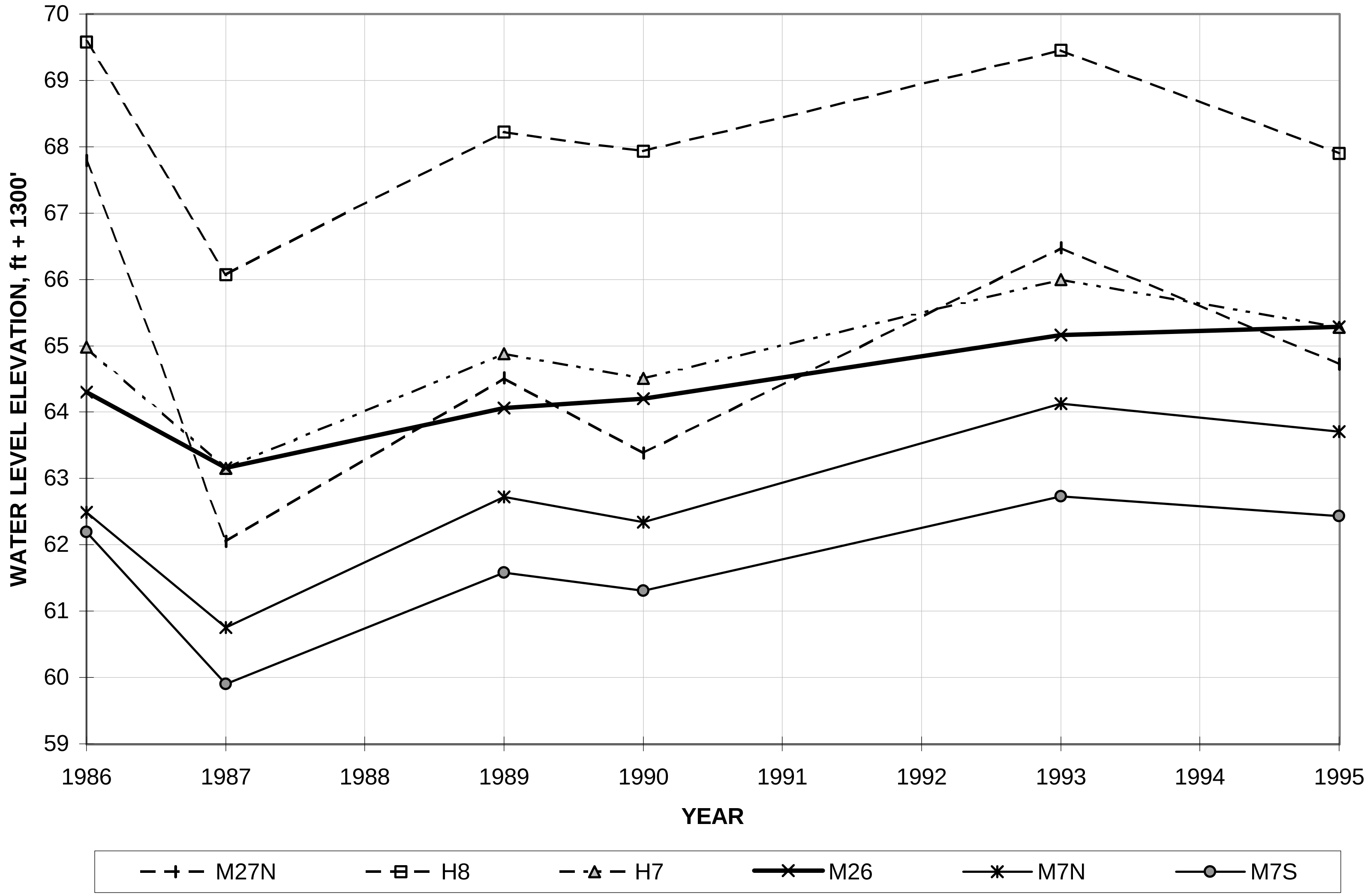


FIGURE 11. ELEVATION OF WATER LEVEL IN OCTOBER FROM 1986-1995: M5E & M5W (shallow and deep piezometer, Tailings Basin)

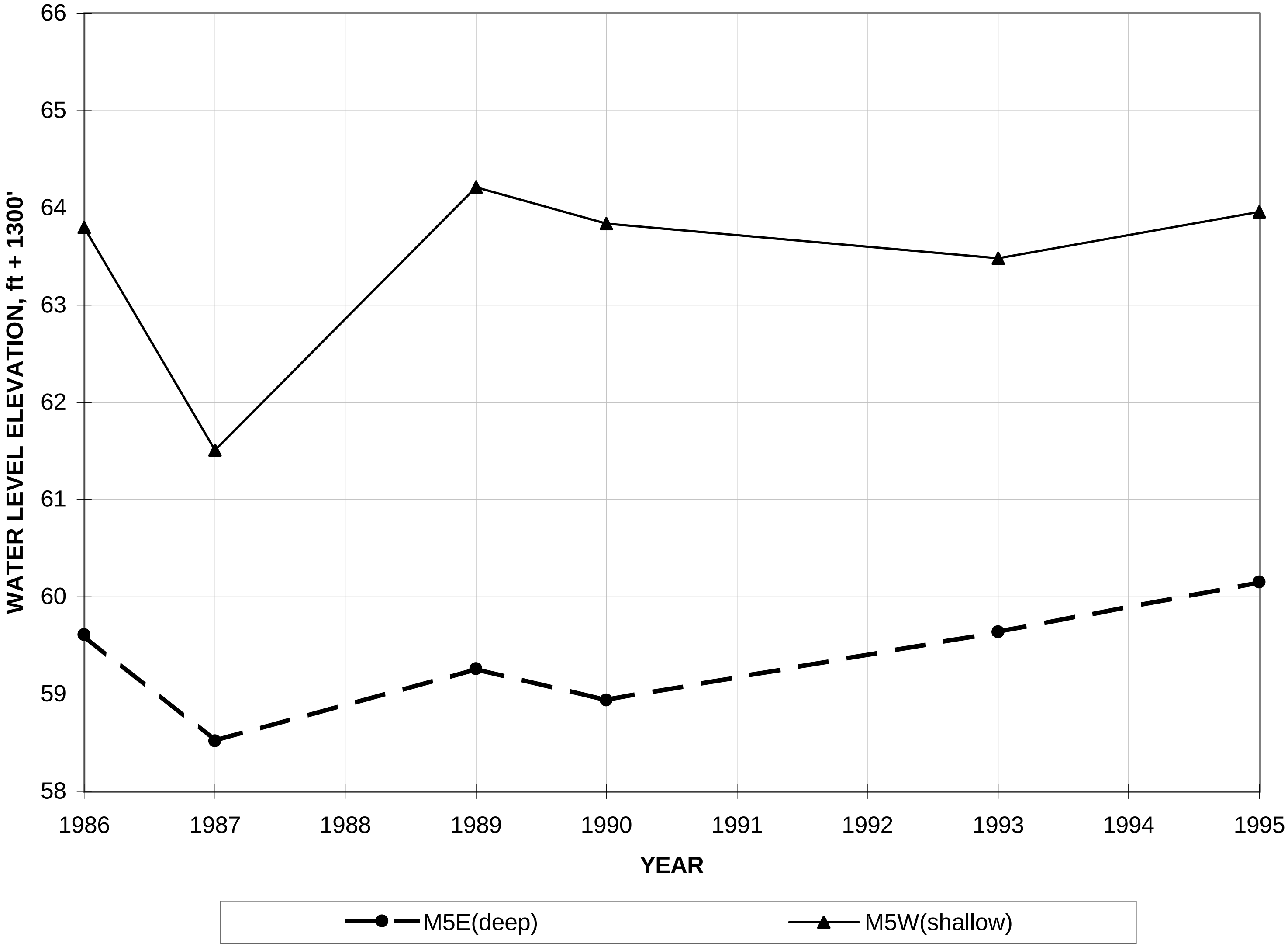


FIGURE 12. ELEVATION OF WATERLEVEL IN OCTOBER FROM 1986-1995: M39, M34, M3, M1 & M33 (piezometers north of Tailings Basin)

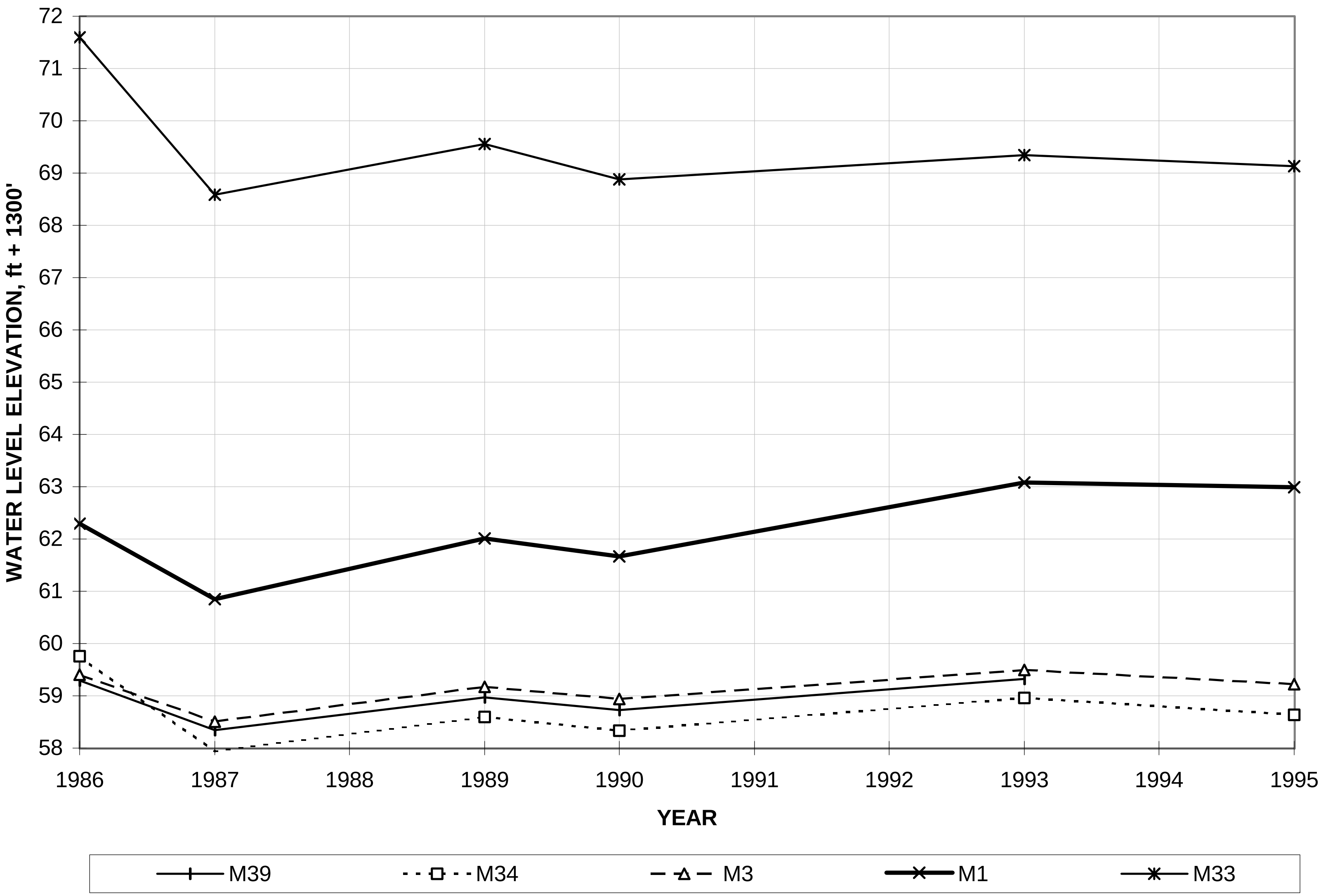
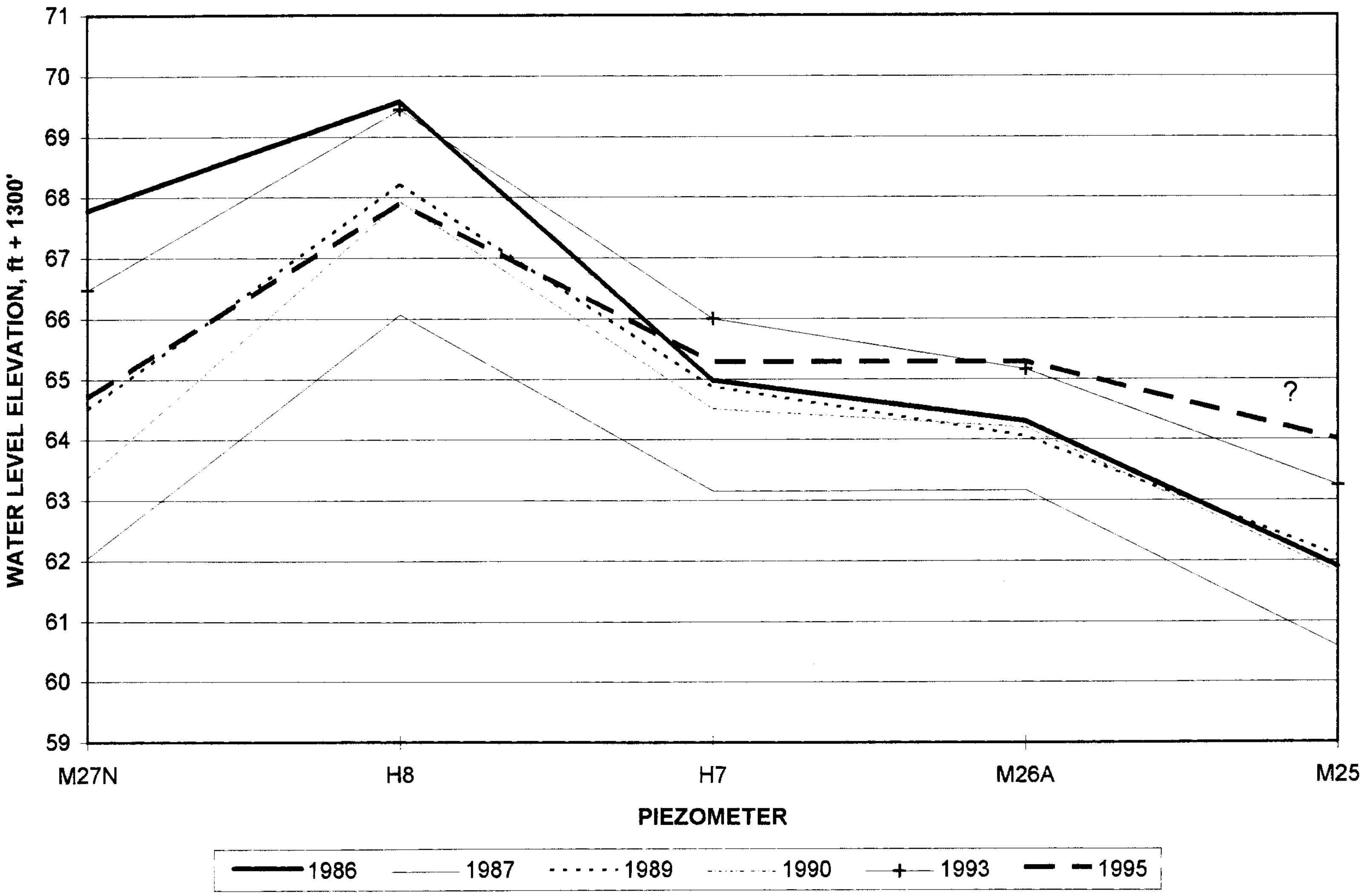


FIGURE 13. CHANGE IN ELEVATION OF WATER LEVEL (OCTOBER) IN PIEZOMETERS: M27B, H8, H7, M26A & M25 OVER PERIOD: 1986-1995 (shallow piezometers, Tailings Basin)



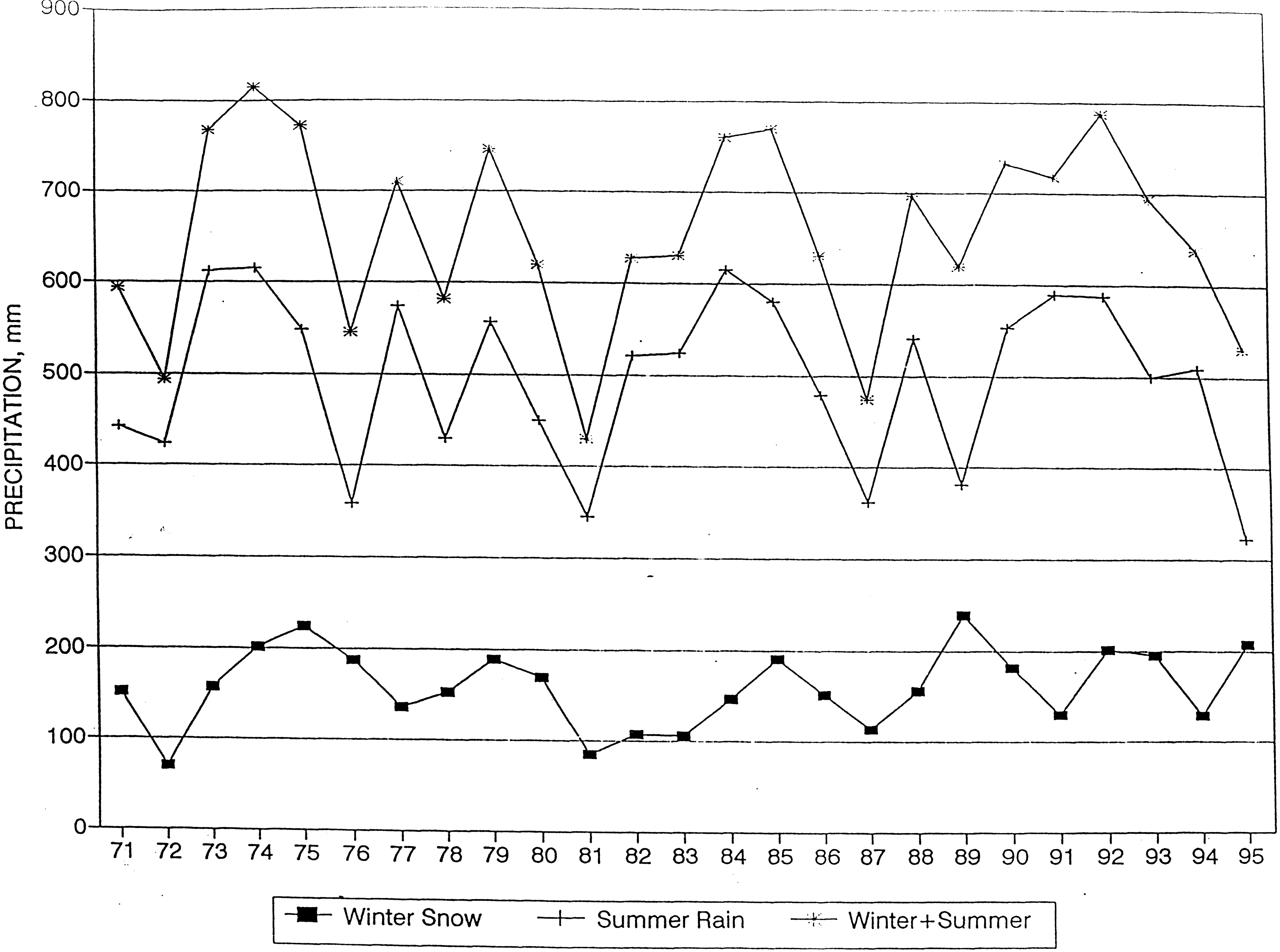


FIGURE 14. PRECIPITATION AT EAR FALLS: 1971 - 1995 (after R.O. van Everdingen, report in preparation)

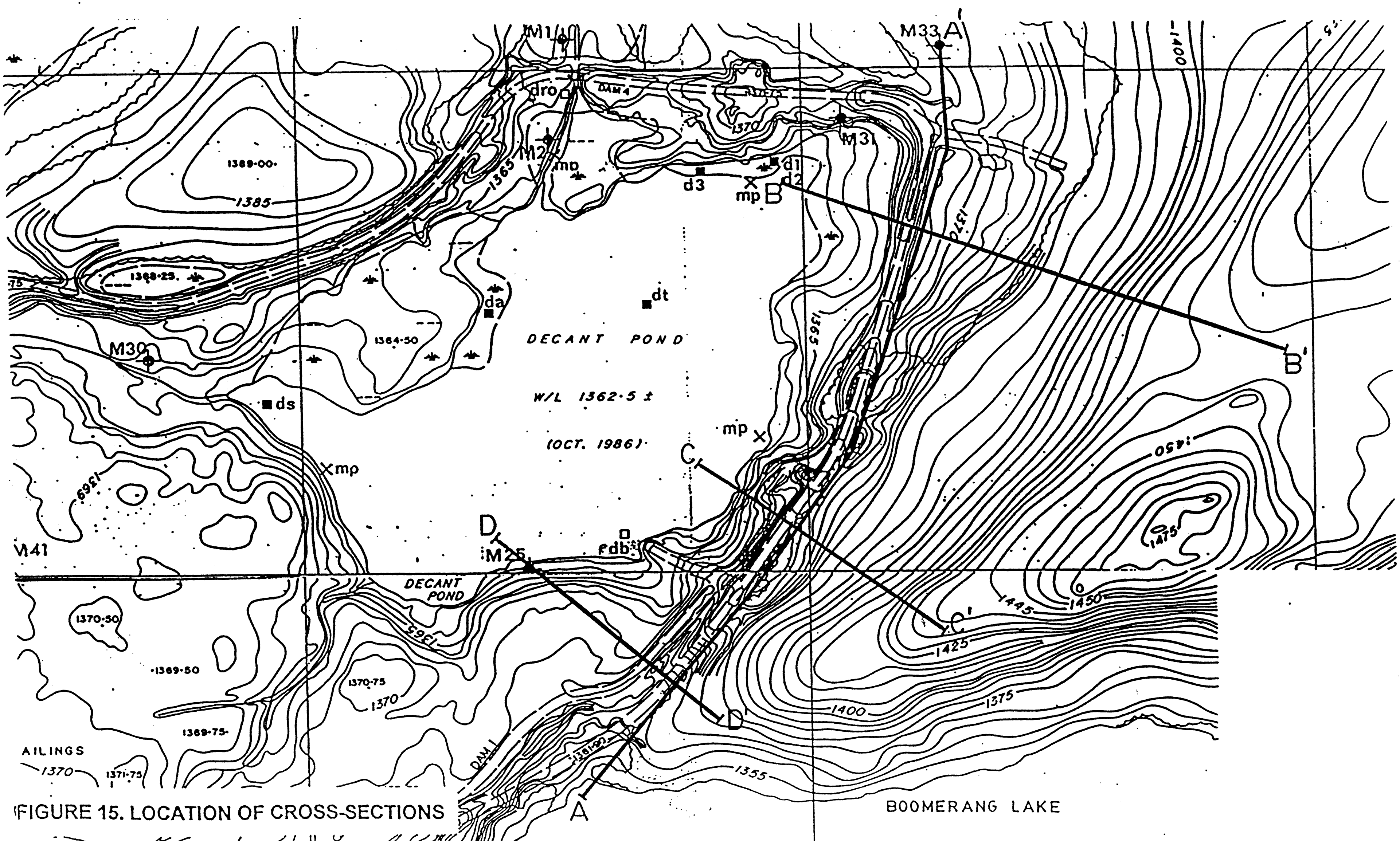


FIGURE 15. LOCATION OF CROSS-SECTIONS

Table 1: Water balance and contaminant loading of selected ions, Mud Lake Area

(based on Table 4, Boojum, 1994)

Percent fresh water set at	94.7%	of Mud Lake Outflow minus DRO flow, =	11.44	L/s
Therefore, groundwater inflow is	5.3%	of Mud Lake Outflow minus DRO flow		

	DRO Loadings mg/s	Freshwater Loading ML29 mg/s@ 10.83 L/s	Groundwater Loading ML27 Bottom mg/s@ 0.61 L/s	DRO+FW +GW Loading, mg/s	M.L. Outflow, ML18 Loadings mg/s	%Diff. ('-' = loss)
TDS	784	1690	7822	10296	11262	9%
Na	4	4	9	17	36	110%
Cl	1	17	14	32	32	0%
S	120	317	2061	2499	3041	22%
Zn	3	1	112	116	97	-16%
Al	0	0	0	0	2	572%
Fe	0	2	1085	1081	287	-74%
K	17	48	14	79	33	-58%
Ca	270	412	308	990	1323	34%

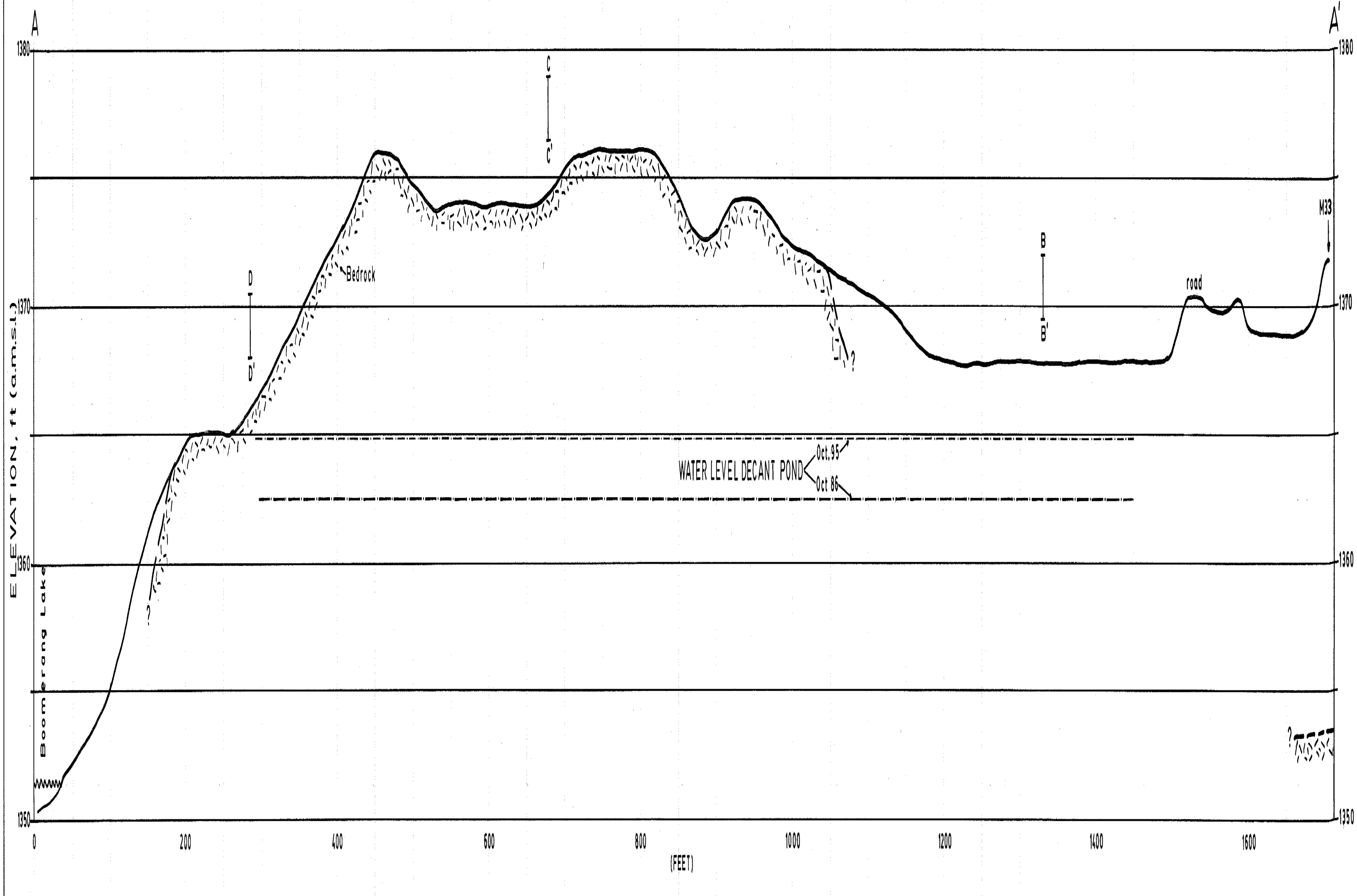


PLATE 1: TOPOGRAPHIC CROSS-SECTION A-A'
SOUTH BAY, ONTARIO

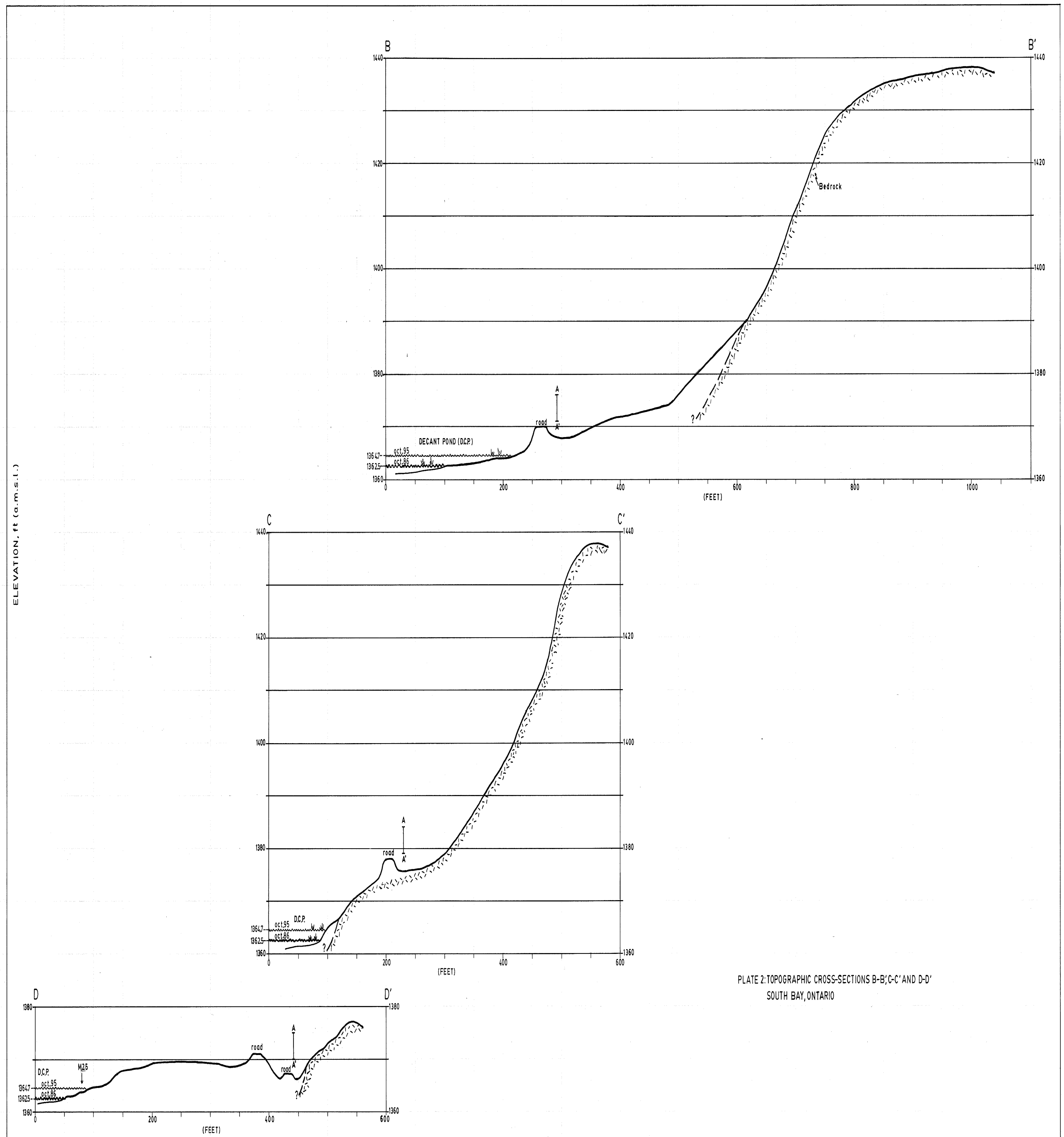


PLATE 2: TOPOGRAPHIC CROSS-SECTIONS B-B′, C-C′ AND D-D′
SOUTH BAY, ONTARIO